

5 3

McGRAW-HILL
BOOK COMPANY

New York
St. Louis
San Francisco
Düsseldorf
Johannesburg
Kuala Lumpur
London
Mexico
Montreal
New Delhi
Panama
Paris
São Paulo
Singapore
Sydney
Tokyo
Toronto

C. O. BENNETT

*Professor of Chemical Engineering
University of Connecticut
Storrs*

J. E. MYERS

*Professor of Chemical and
Nuclear Engineering
University of California
Santa Barbara*

Momentum, Heat, and Mass Transfer

SECOND EDITION

This book was set in Times New Roman.
The editors were B. J. Clark and Matthew Cahill;
the production supervisor was Thomas J. LoPinto.
New drawings were done by John Cordes, J & R Technical Services, Inc.
The Maple Press Company was printer and binder.

Library of Congress Cataloging in Publication Data

Bennett, Carroll O
Momentum, heat, and mass transfer.
(Chemical engineering series)
Includes bibliography.
I. Transport theory. 2. Chemical engineering.
I. Myers, John Earle, date joint author.
II. Title.
TP156.T7B46 1974 660.2'842 73-13857
ISBN 0-07-004667-0

**MOMENTUM,
HEAT, AND
MASS TRANSFER**

Copyright © 1962, 1974 by McGraw-Hill, Inc. All rights reserved.
Printed in the United States of America. No part of this publication may be reproduced,
stored in a retrieval system, or transmitted, in any form or by any means,
electronic, mechanical, photocopying, recording, or otherwise,
without the prior written permission of the publisher.

4567890MAMM79876

1
Part 1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

CONTENTS

| | |
|--|-----|
| Preface | ix |
| <i>1</i> Introduction | i |
| Part 1 Fluid Dynamics | |
| 2 The Overall Balances; Introduction to Fluid Behavior | 15 |
| 3 The Overall Mass Balance | 28 |
| 4 The Overall Energy Balance | 40 |
| 5 The Overall Momentum Balance | 61 |
| 6 Flow Measurement | 71 |
| 7 The Differential Mass Balance | 86 |
| 8 The Differential Energy Balance | 93 |
| 9 The Differential Momentum Balance | 99 |
| 10 Some Solutions of the Equations of Motion | 112 |
| 11 Boundary-Layer Flow | 131 |
| 12 Velocity Distribution and Drag with Turbulent Flow | 147 |
| 13 Dimensional Analysis with Applications in Fluid Dynamics | 175 |
| 14 Some Design Equations for the Flow of Incompressible Fluids | 193 |
| 15 Filtration | 218 |

| | |
|--|-----|
| Part 2 Heat Transfer | |
| 16 Introduction to Heat Transfer | 243 |
| 17 Conduction and Thermal Conductivity | 246 |
| 18 Steady-State Heat Conduction | 254 |
| 19 Unsteady-State Heat Conduction | 267 |
| 20 Numerical, Graphical, and Analog Methods in the Analysis of Heat Conduction | 286 |
| 21 Convective Heat-Transfer Coefficients | 303 |
| 22 Heat Transfer with Laminar Flow | 326 |
| 23 Heat Transfer with Turbulent Flow | 347 |
| 24 Some Design Equations for Convective Heat Transfer | 370 |
| 25 Boiling and Condensation | 398 |
| 26 Radiant Heat Transfer | 418 |
| 27 Heat-Exchange Equipment | 447 |
| Part 3 Mass Transfer | |
| 28 Introduction to Mass Transfer | 477 |
| 29 Molecular Diffusion and Diffusivity | 481 |
| 30 Diffusion in Binary Mixtures | 492 |
| 31 Convective Mass-Transfer Coefficients | 513 |
| 32 Mass Transfer with Laminar Flow | 534 |
| 33 Mass Transfer with Turbulent Flow | 544 |
| 34 Some Design Equations for Convective Mass Transfer | 561 |
| 35 Continuous Contacting of Immiscible Phases | 582 |
| 36 Simultaneous Momentum, Heat, and Mass Transfer | 607 |
| 37 Separation by Equilibrium Stages; Immiscible Phases | 640 |
| 38 Contacting of Partially Miscible Phases | 662 |
| 39 Distillation of Binary Mixtures | 680 |
| 40 Multicomponent Separations | 732 |
| Appendixes | 753 |
| Index | 797 |

This book heat, and claim to c discussed. the theory excessive c A be introductio texts in fl However, seems to u which can important the reader We i and show in the ho needs then

1/9/1

DIALOG(R)File 351:Derwent WPI

(c) 2000 Derwent Info Ltd. All rts. reserv.

009090418 **Image available**

WPI Acc No: 1992-217838/199227 XRPX Acc No: N92-165425

Removal of artificial joints - with focussed ultrasonic head to loosen cement around joint support

Patent Assignee: SIEMENS AG (SIEI)

Inventor: HASSLER D

Number of Countries: 001 Number of Patents: 001

Patent Family:

| Patent No | Kind | Date | Applicat No | Kind | Date | Week |
|------------|------|----------|-------------|------|----------|----------|
| DE 4041063 | A | 19920625 | DE 4041063 | A | 19901220 | 199227 B |

Priority Applications (No Type Date): DE 4041063 A 19901220

Patent Details:

| Patent No | Kind | Lan Pg | Main IPC | Filing Notes |
|------------|------|--------|-------------|--------------|
| DE 4041063 | A | 17 | A61F-002/46 | |

Abstract (Basic): DE 4041063 A

The ultrasonic head (10,9) has a shaped end to fit over the joint (3) and to direct ultrasonic vibrations through the joint and into the current which fixes the joint into the bone. The ultrasonic vibration is selected to destroy the cement with no damage to the surrounding bone. The joint can then be removed and replaced.

The piezoelectric transducer (10) provides the vibrations which are focussed by a shaped connecting element. The focus of the vibrations is the centre of the joint and the vibrations in the cement are shear waves. Magnetostrictive vibration generators can also be used.

USE/ADVANTAGE - Safe removal of joints, no excessive force required, minimum damage risk to bones.

Dwg.1/9

Title Terms: REMOVE; ARTIFICIAL; JOINT; FOCUS; ULTRASONIC; HEAD; LOOSE; CEMENT; JOINT; SUPPORT

Derwent Class: P32; P43; P86; S05; V06

International Patent Class (Main): A61F-002/46

International Patent Class (Additional): B06B-001/04; B06B-001/06; B06B-001/08; B06B-003/04; G10K-011/02

File Segment: EPI; EngPI

Manual Codes (EPI/S-X): S05-B02; S05-F03; V06-D